

# Level 5 Advanced Technician Diploma in Civil Engineering

**(9209-13)**

October 2014 Version 1.5



## Qualification at a glance

<b>Subject area</b>	<b>Engineering</b>
<b>City &amp; Guilds number</b>	9209-13
<b>Age group approved</b>	18+
<b>Entry requirements</b>	N/A
<b>Assessment</b>	<ul style="list-style-type: none"> <li>• Centre set and marked assignment</li> <li>• Externally set, internally marked assignments</li> <li>• Dated written papers</li> </ul>
<b>Fast track</b>	N/A
<b>Support materials</b>	<ul style="list-style-type: none"> <li>• Qualification handbook</li> <li>• Assessment pack</li> <li>• Online tutor and learner support material</li> </ul>
<b>Registration and certification</b>	Consult the Walled Garden/Online Catalogue for last dates

<b>Title and level</b>	<b>City &amp; Guilds number</b>	<b>Accreditation number</b>
Level 5 Advanced Technician Diploma in Civil Engineering	9209-13	601/5534/6

<b>Version and date</b>	<b>Change detail</b>	<b>Section</b>
V1.1 Oct 2014	Test specifications added. Grading information added.	4 Assessment 5 Grade profile
V1.2 Oct 2014	Items added unit 523 range.	6 Units
V1.3 Dec 2014	Range amended (unit 520). Test specification updated (unit 520). Qualification title updated. Inconsistent titling addressed (unit 520).	6 Units Test specifications  Throughout Throughout
V1.4 Jan 2015	UAN numbers and QAN added.	1 Introduction (Structure) and 6 Units
V1.5 March 2015	Minor amendment to assessment strategy regarding sample questions	4 Assessment



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# 1 Introduction

This document tells you what you need to do to deliver the qualification:

<b>Area</b>	<b>Description</b>
Who is the qualification for?	It for learners who work or want to work as Civil Engineers in the Engineering sector
What opportunities for progression are there?	It allows learners to progress into employment or to the following City & Guilds qualifications: <ul style="list-style-type: none"><li>• Level 6 Graduate Diploma in Civil Engineering</li><li>• Level 7 Post Graduate Diploma in Civil Engineering</li></ul>

## Structure

To achieve the **Level 5 Advanced Technician Diploma in Civil Engineering** learners must achieve all **three** mandatory units and **four** optional units.

City & Guilds unit number/UAN	Unit title	Unit Level	GLH	NLH
<b>Mandatory units</b>				
Unit 520 T/506/9254	Advanced Mathematics for Civil Engineering	5	60	200
Unit 521 A/506/9255	Design of Structural Elements	5	60	200
Unit 522 F/506/9256	Integrated Civil Engineering Design Project	5	60	200
<b>Optional units</b>				
Unit 422 A/506/9305	Personal and Professional Development	4	25	100
Unit 504 D/506/9264	Project Management	5	50	150
Unit 523 J/506/9257	Advanced Surveying Technology	5	60	200
Unit 524 L/506/9258	Environmental Water Engineering	5	60	200
Unit 525 R/506/9259	Transport Engineering	5	60	200
Unit 526 J/506/9260	Measurement, Costing and Contracts for Civil Engineers	5	60	200
Unit 527 L/506/9261	Pavement Design	5	60	200

Unit 528 R/506/9262	Concrete Design	5	60	200
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Unit 529 Y/506/9263	Sustainable Development	5	60	200
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## 2 Centre requirements

### Approval

If there is no fast track approval for this qualification, existing centres who wish to offer this qualification must use the **standard** Qualification Approval Process.

### Resource requirements

#### Physical resources and site agreements

The equipment, systems and machinery must meet industrial standards and be capable of being used under normal working conditions.

#### Centre staffing

Staff delivering this qualification must be able to demonstrate that they meet the following occupational expertise requirements. They should:

- be occupationally competent or technically knowledgeable in the areas for which they are delivering training and experience of providing training. This knowledge must be to the same level as the training being delivered
- Trainers must hold or be working towards a recognised training qualification.
- have recent relevant experience in the specific area they will be assessing
- have credible experience of providing training.

Centre staff may undertake more than one role, eg tutor and assessor or internal quality assurer, but cannot internally verify their own assessments.

### Assessors and Internal Quality Assurer

#### Assessors

Although not specifically required for this qualification, City & Guilds recommends that Assessors hold, or are working towards, the relevant Level 3 TAQA qualification, covering the assessment types required for this qualification. Further information about the City & Guilds TAQA qualification can be found at **[www.cityandguilds.com](http://www.cityandguilds.com)**. Assessors must be able to demonstrate clear experience in assessing learning and understand City & Guilds' quality assurance requirements. They must also have the required industry certification and experience as outlined above.

#### Internal Verifiers / Internal Quality Assurers

Although not specifically required for this qualification, City & Guilds recommends that Internal Verifiers / Internal Quality Assurers hold, or are working towards, the Level 4 TAQA qualification. Further information about the City & Guilds TAQA qualification can be found at

**www.cityandguilds.com**. Internal Verifiers / Internal Quality Assurers must be able to demonstrate clear experience in quality assurance processes and understand City & Guilds' specific quality assurance requirements. They must also have the required industry certification and experience as outlined above.

### **Continuing professional development (CPD)**

Centres must support their staff to ensure that they have current knowledge of the occupational area, that delivery, mentoring, training, assessment and verification is in line with best practice, and that it takes account of any national or legislative developments.

### **Learner entry requirements**

Learners should already hold the Level 4 Diploma in Civil Engineering or equivalent in order to complete the qualification satisfactorily.

### **Age restrictions**

City & Guilds cannot accept any registrations for learners under 18.





### 3 Delivering the qualification

#### Initial assessment and induction

An initial assessment of each learner should be made before the start of their programme to identify:

- if the learner has any specific training needs,
- support and guidance they may need when working towards their qualification.
- any units they have already completed, or credit they have accumulated which is relevant to the qualification.
- the appropriate type and level of qualification.

We recommend that centres provide an induction programme so the learner fully understands the requirements of the qualification, their responsibilities as a learner, and the responsibilities of the centre. This information can be recorded on a learning contract.

#### Support materials

The following resources are available for this qualification:

Description	How to access
Sample exam questions	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
Assignment guide	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
Sample schemes of work	<a href="http://www.smartscreen.co.uk">www.smartscreen.co.uk</a>
Further reading /links	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
Equipment lists	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
Recognition lists	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>



## 4 Assessment

City & Guilds has written the following assessments to use with this qualification:

<b>Unit</b>	<b>Title</b>	<b>Assessment method</b>	<b>Where to obtain assessment materials</b>
422	Personal and Professional Development	Assignment set by City & Guilds, internally marked, externally verified	<b>www.cityandguilds.com</b>
504	Project Management	Assignment set by City & Guilds, internally marked, externally verified	<b>www.cityandguilds.com</b>
520	Advanced Mathematics for Civil Engineering	Dated entry written exam paper	Question papers ordered via Walled Garden
521	Design of Structural Elements	Assignment set by City & Guilds, internally marked, externally verified	<b>www.cityandguilds.com</b>
522	Integrated Civil Engineering Design Project	Assignment set by City & Guilds, internally marked, externally verified	<b>www.cityandguilds.com</b>
523	Advanced Surveying Technology	Assignment set by City & Guilds, internally marked, externally verified	<b>www.cityandguilds.com</b>
524	Environmental Water Engineering	Dated entry written exam paper	Question papers ordered via Walled Garden

<b>Unit</b>	<b>Title</b>	<b>Assessment method</b>	<b>Where to obtain assessment materials</b>
525	Transport Engineering	Assignment set by City & Guilds, internally marked, externally verified	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
526	Measurement, Costing and Contracts for Civil Engineers	Assignment set by City & Guilds, internally marked, externally verified	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
527	Pavement Design	Assignment set by City & Guilds, internally marked, externally verified	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
528	Concrete Design	Assignment set by City & Guilds, internally marked, externally verified	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
529	Sustainable Development	Assignment set by City & Guilds, internally marked, externally verified	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>

## Test specifications

The way the knowledge is covered by each test is laid out in the tables below:

**Test 1:** Unit 520 Advanced Mathematics for Civil Engineering  
**Duration:** 3 hours  
**Grading:** Pass/Merit/Distinction

<b>Outcome</b>	<b>Number of marks</b>	<b>%</b>
1 Be able to use matrix algebra to solve civil engineering problems	15	15
2 Be able to use vectors methods to solve civil engineering problems	10	10
3 Be able to use differential and integral calculus to solve civil engineering problems	20	20
4 Be able to apply numerical analysis to solve civil engineering problems	20	20
5 Understand forms of statistical distribution	5	5
6 Be able to use statistical tests	20	20
7 Be able to use linear regression techniques	10	10
<b>Total</b>	<b>100</b>	<b>100</b>

**Test 2:** Unit 524 Environmental Water Engineering  
**Duration:** 3 hours  
**Grading:** Pass/Merit/Distinction

<b>Outcome</b>	<b>Number of marks</b>	<b>%</b>
1 Understand legislation governing water and wastewater	20	20
2 Know how to identify the nature of sewage and sewerage systems	15	15
3 Be able to identify sewage and sewerage systems	15	15
4 Understand water treatment	30	30
5 Understand the principles of wastewater treatment	20	20
<b>Total</b>	<b>100</b>	<b>100</b>

## Time constraints

The following time constraints must be applied to the assessments of this qualification:

- each assignment has suggested durations ; please refer to the individual assignments and to the Assessor Guidance. Centre staff should guide learners to ensure excessive evidence gathering is avoided. Centres finding that assignments are taking longer, should contact the Qualification consultant for guidance
- all assignments must be completed and assessed within the learner's period of registration. Centres should advise learners of any internal timescales for the completion and marking of individual assignments
- all dated entry written exam papers must be sat within the learner's period of registration.

## Assessment strategy

City & Guilds provide sample questions for each unit assessed by dated entry written exam paper.

The purpose of these sample questions is to provide examples of the type of question that will be set, giving an indication of the breadth and depth of knowledge that is expected. It should be noted that these are sample questions and **not** a full sample question paper.

Dated entry examinations will take place in June and December, with the first exam series in June 2015.

## Recognition of prior learning (RPL)

Recognition of prior learning means using a person's previous experience or qualifications which have already been achieved to contribute to a new qualification.

RPL is not allowed for this qualification.

## 5 Grade profile

### Purpose and use of this qualification grade profile

City & Guilds has taken the decision to grade the individual assessments included in this qualification, and provide a grade associated with each unit. This decision is based on market research with employers and colleges that suggests grading can be of use both as a motivational tool within the learning environment, and also to learners presenting evidence of their skills to prospective employers.

For this reason, the tasks have been developed to extend learners beyond the minimum required for Pass. As a basis for developing the tasks and their related grading criteria, City & Guilds consulted a number of stakeholders to discover what the grades at each level should mean in practice, and how they might be used. The following descriptors are based on that consultation.

The descriptors were used in the development of the task grading criteria and should be used by assessors to understand the intended outcomes of the grading.

They should be referred to during the centre's standardising exercises in addition to the specific grading criteria for the unit to support a consistent understanding of the standard across units, centres and assessors. The grades achieved by a learner would be considered by universities for subsequent entry into the correct year of a degree programme.

### Levels

#### Level 4

The Level 4 Diplomas in Civil Engineering focus on advanced engineering. The learners will have the potential to fulfil a role within Engineering that requires a high level of responsibility, for example within first level management, requiring the use of personal initiative and critical judgement.

Holders of these qualifications may also be able to advance into the second year of a selected university engineering degree programme.

#### Level 5

The Level 5 Advanced Technician Diplomas in Civil Engineering focus on advanced engineering. The learner will have the potential to fulfil a role within Engineering that requires a high level of responsibility, for example leading to middle management and/or project management, requiring the use of personal initiative and critical judgement.

Holders of these qualifications may also be able to advance into the third year of a selected university engineering degree programme.

To take this qualification a learner must first achieve the 9209 Level 4 Diploma in Civil Engineering.

### Delivery of learning

Learning is delivered by approved colleges and training providers in simulated learning environments, not in the workplace. Learners will however have access to real work environments in which to further develop the breadth of their skills and their experience.

## Grading

The majority of tasks are graded Pass / Merit / Distinction. Pass reflects the minimum requirements that are expressed in the unit, with Merit and Distinction showing progression in skills and knowledge as well as recognising behaviours important to the industry.

	Pass	Merit	Distinction
Level 4	<p><b>Learner:</b> Capable of making informed decisions, likely to have achieved a grade at Level 3 (Merit / Distinction), starting to have sufficient skills to bring value to the industry, is becoming comfortable with occupational systems and procedures.</p> <p><b>Evidence:</b> Complex tasks may present some challenge, partial attempt at assessment, well defined tasks completed with a level of guidance, able to follow the required process, acceptable skills / knowledge / competence displayed for the industry, can plan, can solve problems.</p> <p>Limited reflection on the outcomes of the task.</p>	<p><b>Learner:</b> Broader understanding of systems and procedures, can work with minimal guidance, determination to resolve issues, taking ownership and responsibility for own learning, desire to progress.</p> <p><b>Evidence:</b> Full attempt at assessment, well defined tasks completed with minimal guidance, able to follow the required process, higher level skills / knowledge / competence displayed for the industry, can plan, can solve problems more effectively and confidently.</p> <p>Sufficient reflection on the outcomes of the task.</p>	<p><b>Learner:</b> High level of understanding and evaluation of overall systems and procedures, showing potential to achieve a higher level of academic study. Has an ability to carry out tasks without guidance and shows own initiative.</p> <p><b>Evidence:</b> Full achievement of assessment completely independently, within the time given, ie efficient use of time.</p> <p>Detailed / in-depth reflection on the outcomes of the task with recommendations for improvement / alternatives.</p>

	Pass	Merit	Distinction
<b>Level 5</b>	<p><b>Learner:</b> Capable of making informed decisions, likely to have achieved a grade at Level 4 (Merit / Distinction), has sufficient skills to bring value to the industry, is fairly comfortable with occupational systems and procedures.</p> <p><b>Evidence:</b> Complex tasks may present some challenge, but most assessments attempted, well defined tasks completed with a level of guidance, able to follow the required process, acceptable skills / knowledge / competence displayed for the industry, can plan, can solve problems.</p> <p>Satisfactory reflection on the outcomes of the task.</p>	<p><b>Learner:</b> Full understanding of systems and procedures, can work with minimal to no guidance, determination to resolve issues, taking ownership and responsibility for own learning, desire to excel.</p> <p><b>Evidence:</b> Full attempt at assessment, well defined tasks completed with minimal guidance, able to follow the required process, higher level skills / knowledge / competence displayed for the industry, can plan, can solve problems more effectively and confidently.</p> <p>Good reflection on the outcomes of the task.</p>	<p><b>Learner:</b> High level of understanding, evaluation and competence in overall systems and procedures, clearly achieving a higher level of academic study. Has an ability to carry out tasks without guidance and shows own initiative.</p> <p><b>Evidence:</b> Full achievement of assessment completely independently, within the time given, ie efficient use of time.</p> <p>Detailed / in-depth reflection on the outcomes of the task with recommendations for improvement / alternatives.</p>





## 6 Units

### Structure of units

These units each have the following:

- City & Guilds reference number
- title
- level
- guided learning hours
- notional learning hours
- unit aim
- information on assessment
- learning outcomes which are comprised of a number of assessment criteria
- notes for guidance.

<b>Level:</b>	4
<b>UAN:</b>	A/506/9305
<b>GLH:</b>	25
<b>Assessment method:</b>	Assignment
<b>Aim:</b>	The purpose of this unit is to enable learners to develop an understanding of the different methods and resources available to them for planning their personal and professional development.

They will learn how to identify factors that may affect targets or goals, prioritise actions and understand how feedback from others can be utilised to aid their development and career progression. They will be able to develop a plan which can either be used during progress of a course of study or as a tool in their future careers.

<b>Learning outcome</b>
The learner will: 1. understand how to plan for personal and professional development
<b>Assessment criteria</b>
The learner can: 1.1 describe the <b>benefits</b> of personal and professional development 1.2 identify <b>development opportunities</b> for career and personal progression 1.3 analyse development opportunities that may support career and personal progression.

<b>Range</b>
<p><b>Benefits</b></p> <p>personal - update skills, gain new skills, increase motivation, confidence</p> <p>professional - career progression, meeting organisation goals, how role fits into organisation</p> <p><b>Development opportunities</b></p> <ul style="list-style-type: none"> <li>• internal and external</li> <li>• skills: inter-personal, enterprise, self-management and leadership</li> <li>• knowledge: qualifications</li> </ul>

<b>Learning outcome</b>
The learner will:
2. understand how people learn
<b>Assessment criteria</b>
The learner can:
2.1 explain the <b>principles</b> of how people learn
2.2 describe different <b>learning styles</b>
2.3 evaluate <b>learning resources</b> to support development
2.4 analyse the use of different <b>learning strategies</b> .

<b>Range</b>
<p><b>Principles</b></p> <p>relevant theories, methodologies, pedagogies, codes of ethics</p> <p><b>Learning styles</b></p> <p>visual, aural, physical, logical, social, solitary</p> <p><b>Learning resources</b></p> <p>libraries; organisation's resources, IT, internet, progress files, portfolio development</p> <p><b>Learning strategies</b></p> <p>awareness of personal style e.g. activist, pragmatist, theorist, reflector, interactions with others, taking responsibility for own development, effective time-management, structured reflection</p>

<b>Learning outcome</b>
The learner will:
3. be able to produce personal and professional development plans
<b>Assessment criteria</b>
The learner can:
3.1 carry out <b>self-audit</b> of skills and experience
3.2 identify <b>targets</b> for personal and professional development
3.3 use <b>methods</b> to track personal development
3.4 create a personal and professional development plan.

<b>Range</b>
<p><b>Self-audit</b> personal reflections, feedback from others; skills scan; revisiting job role</p> <p><b>Targets</b> SMART target setting, responding to feedback, realigning targets, addressing strengths and weaknesses</p> <p><b>Methods</b> task manager, blog, project management tools, diaries, performance review/plan, objectives, monitoring, reflecting and planning</p>

<b>Learning outcome</b>
<p>The learner will:</p> <p>4. be able to make recommendations for personal and professional development</p>
<b>Assessment criteria</b>
<p>The learner can:</p> <p>4.1 explain the <b>benefits</b> of reflective practice</p> <p>4.2 evaluate <b>progress</b> against development plan</p> <p>4.3 recommend opportunities for further development.</p>

<b>Range</b>
<p><b>Benefits</b> extent to which targets have been met/not met, recognise any changes in expectations; suggest further support required, identify barriers to progress</p> <p><b>Progress</b> the learner should regularly identify progress against original plan and refine plan accordingly</p>

<b>Level:</b>	5
<b>UAN:</b>	D/506/9264
<b>GLH:</b>	50
<b>Proposed assessment method:</b>	Assignment
<b>Aim:</b>	The purpose of this unit is to enable learners to develop an understanding of the principles of project management in civil engineering and how projects are set up. Learners will gain an understanding of how to mitigate risks and how to develop management skills to monitor and review civil engineering projects.

<b>Learning outcome</b>
The learner will: 1. understand why organisations use project management
<b>Assessment criteria</b>
The learner can: 1.1 describe the <b>principles</b> of project management 1.2 explain the <b>benefits</b> of project management to organisations and individuals.

<b>Range</b>
<b>Principles</b> application of technical knowledge to project management; leadership; delegation; negotiation; decision-making; defined roles and responsibilities; management by stages; management by exception; focus on outcomes; determination of objectives; recognition of constraints; lifecycle planning; ethical and professional issues; learning from experience; application of project management principles to civil engineering projects
<b>Benefits</b> increased efficiency; better understanding of client brief; enhanced communication with main contractor and sub-contractors; improved client satisfaction; more effective delivery of project outcomes; improvements in quality and output; better development opportunities within the project team; increase in competitive edge; opportunities to expand work done; greater flexibility; improved risk assessment.

<b>Learning outcome</b>
The learner will: understand how to set up projects
<b>Assessment criteria</b>
The learner can: 2.1 explain the <b>considerations</b> that apply when reviewing project proposals 2.2 explain <b>how to set clear goals</b> for projects 2.3 analyse project <b>resource requirements</b> 2.4 explain <b>how roles and responsibilities are allocated</b> within project teams 2.5 identify project <b>communication needs</b> 2.6 assess <b>possible risks</b> to successful completion of projects 2.7 explain how to <b>mitigate</b> possible risks.

<b>Range</b>
<b>Considerations</b> financial, legal, technical, environmental, resource, time and budget constraints; dependencies; confidentiality; access to data and project documentation
<b>How to set clear goals</b> co-ordinate and control design and construction; identify stakeholders needs; record goals in project plans; agree contractual relationships with client, design team, construction team and project manager; clarify powers, authority, responsibilities and accountability; define project requirements against identified goals
<b>Resource requirements</b> allocate budget for design costs, labour, materials and construction plant; consider training needs, communication needs and IT requirements; management contracts and the use of subcontractors
<b>How roles and responsibilities are allocated</b> identify expertise from different areas (design, construction, procurement, health and safety); analyse roles of key stakeholders; identify training and development needs; schedule meetings and reports
<b>Communication needs</b> formal/informal communication; identifying who requires communication, e.g. stakeholders, client, management, design team, project realisation team, suppliers, local authority, statutory bodies
<b>Possible risks</b> safety issues; optimistic time and cost estimates; unexpected budget costs; unclear roles and responsibilities; stakeholder needs neither sought nor addressed; changing requirements after the start of the project; new requirements; poor communication; lack of commitment.
<b>Mitigate</b> Use of quality assurance techniques, environmental assessments, risk assessment, soil and material testing, regular project review meetings, appropriate communication and targeted training.

<b>Learning outcome</b>
The learner will: be able to use management tools to maintain, control and monitor projects
<b>Assessment criteria</b>
The learner can: 3.1 describe different <b>management tools</b> for monitoring and control of projects 3.2 justify the use of management tools for monitoring and controlling projects 3.3 use management tools to <b>monitor</b> projects.

<b>Range</b>
<b>Management tools</b> method statements; Gantt charts; precedence diagrams; Critical Path Analyses; lines of balance; time-change diagrams; budget monitoring reports; use of relevant and current project software packages
<b>Monitor</b> update task status; progress of work; re-schedule incomplete tasks as necessary; update project elements; review budgets; coordinate and control subcontractors and suppliers.

<b>Learning outcome</b>
The learner will: 4. be able to review projects at all stages
<b>Assessment criteria</b>
The learner can: 4.1 explain <b>reasons</b> for reviewing projects after completion 4.2 review projects against original proposals.

<b>Range</b>
<b>Reasons</b> to continuously improve design and project realisation; to learn from experience; to identify key resources for future projects; to monitor achievement against original objectives; to highlight issues e.g. health and safety, supply problems, training needs, unforeseen increases in costs, to allow revision and updating of plans, to complete end of project report and facilitate final account

<b>Level:</b>	5
<b>UAN:</b>	T/506/9254
<b>GLH:</b>	60
<b>Proposed assessment method</b>	Dated written paper
<b>Aim:</b>	<p>The purpose of this unit is to enable learners to develop knowledge and understanding of advanced mathematical techniques and be able to apply analytical skills to the solution of civil engineering problems. The knowledge and skills developed are used by other units in the qualification and they also provide a sound basis for extending the study of engineering to a higher level if desired. On completion of this unit, learners will be able to:</p> <ul style="list-style-type: none"> <li>• use matrix algebra methods to describe and solve engineering problems</li> <li>• use vector methods of analysis to solve engineering problems</li> <li>• use calculus to model and solve engineering problems</li> <li>• use numerical analysis techniques to solve engineering problems</li> <li>• carry out statistical tests.</li> </ul>

<b>Learning outcome</b>
The learner will:
1. be able to use matrix algebra to solve civil engineering problems
<b>Assessment criteria</b>
The learner can:
1.1 perform <b>operations</b> in matrix algebra
1.2 evaluate the <b>determinants</b> of a matrix
1.3 solve simultaneous equations using Cramer's rule
1.4 obtain the <b>inverse of a square matrix</b>
1.5 apply <b>Gaussian elimination</b> to solve simultaneous equations
1.6 apply matrix algebra to solve engineering problems described by sets of simultaneous equations.



<b>Range</b>
<p><b>Operations</b> sums, differences, multiplication by a scalar constant, product; transpose of a matrix, identity matrix</p> <p><b>Determinants</b> evaluate minors and cofactors; apply rules for simplifying determinants</p> <p><b>Inverse of a square matrix</b> matrix form of simultaneous equations; singular and non-singular matrices; obtain the inverse of a square matrix by formula or by row transformations</p> <p><b>Gaussian elimination</b> the augmented matrix; systematic elimination in the augmented matrix by row transformations</p>

<b>Learning outcome</b>
The learner will: 2. be able to use vectors methods to solve civil engineering problems
<b>Assessment criteria</b>
The learner can: 2.1 perform <b>operations</b> with vectors 2.2 solve civil engineering problems using vectors.

<b>Range</b>
<p><b>Operations</b> vector addition, scalar multiplication; obtain scalar and vector products of two vectors; obtain the vector equation of a line and a plane</p>

<b>Learning outcome</b>
The learner will: 3. be able to use differential and integral calculus to solve civil engineering problems
<b>Assessment criteria</b>
The learner can: 3.1 determine first and higher order derivatives of <b>functions</b> 3.2 use <b>differential calculus</b> to solve problems 3.3 determine indefinite and definite <b>integrals</b> of algebraic and trigonometric functions and differential equations 3.4 use integral calculus to solve <b>problems</b> .

<b>Range</b>
<p><b>Functions</b> algebraic, trigonometric, logarithmic</p> <p><b>Differential calculus</b> product rule; quotient rule; chain rule; maximum and minimum values of a function; points of inflection</p>

**Integrals**

indefinite integrals; table of integrals for common functions (constant,  $ax^n$  ( $n \neq -1$ ),  $1/x$ ,  $\sin(ax \pm b)$ ,  $\cos(ax \pm b)$ ,  $e^{(ax \pm b)}$ ); definite integrals; Integration methods: integration by parts; by substitution; using partial fractions

**Problems**

applications of integration to areas; volumes of revolution; centres of mass; moments of inertia

**Learning outcome**

The learner will:

4. be able to apply numerical analysis to solve civil engineering problems.

**Assessment criteria**

The learner can:

- 4.1 use numerical **iterative methods** to find the roots of a function
- 4.2 apply **numerical methods of integration** to engineering variables
- 4.3 apply **numerical methods** for the solution of ordinary differential equation models
- 4.4 apply **iterative numerical methods** to the solution of partial differential equation models.

**Range****Iterative methods**

Bisection method; Newton's method

**Numerical methods of integration**

Trapezoidal rule; Simpson's rule;

**Numerical methods**

Euler and improved Euler; Taylor series

**Iterative numerical methods**

Finite difference methods for partial differential equations; solution of sets of linear equations by Jacobi iterative method; Gauss-Seidel iterative method

**Learning outcome**

The learner will:

5. understand forms of statistical distribution

**Assessment criteria**

**The learner can:**

- 5.1 explain the uses of statistical **distribution**
- 5.2 explain the concept of degrees of freedom.

**Range****Distribution**

Normal, Chi squared, Poisson, binomial

<b>Learning outcome</b>
The learner will: 6. be able to use statistical tests
<b>Assessment criteria</b>
<b>The learner can:</b> 6.1 perform <b>statistical tests of difference</b> 6.2 perform <b>statistical tests of correlation.</b>

<b>Range</b>
<b>Statistical tests of difference</b> Student-t for small samples, Chi squared
<b>Statistical tests of correlation</b> Pearson's product-moment <sup>®</sup> , Spearman's rank

<b>Learning outcome</b>
The learner will: 7. be able to use linear regression techniques
<b>Assessment criteria</b>
<b>The learner can:</b> 7.1 perform <b>regression</b> techniques 7.2 make predictions using linear <b>regression</b> techniques.

<b>Range</b>
<b>Regression</b> linear, univariate, bivariate

## **Unit 520**

## **Advanced Mathematics for Civil Engineering**

### Supporting information

Learning Outcome 3 is the same Learning Outcome 3 that appears in Unit 439 Applied Mathematics for Civil Engineering

<b>Level:</b>	5
<b>UAN:</b>	A/506/9255
<b>GLH:</b>	60
<b>Proposed assessment method:</b>	Assignment
<b>Aim:</b>	The purpose of this unit is to enable learners to develop an understanding of the factors that underpin the design of simple structural elements, and to use these to design structural elements in steel, reinforced concrete, masonry and timber, using codes of practice, design handbooks and computer software applications as appropriate.

<b>Learning outcome</b>
The learner will: 1. know the factors that affect the design of structural elements
<b>Assessment criteria</b>
The learner can: 1.1 identify the <b>materials</b> used for <b>structural elements</b> 1.2 describe the <b>sources of information</b> that provide guidance on <b>factors</b> that affect the use of materials.

<b>Range</b>
<b>Materials</b> structural steel, reinforced concrete (RC), masonry, structural timber
<b>Structural elements</b> beams (steel, reinforced concrete (RC), timber), columns (steel, reinforced concrete (RC), timber), reinforced concrete slabs (RC), walls (masonry)
<b>Sources of information</b> standard codes of practice, design handbooks and software applications
<b>Factors</b> loadings (dead, imposed, wind), pressures (earth, water), limit states, load factors, materials factors, design strengths, sectional properties, stability, durability, fire protection

<b>Learning outcome</b>
The learner will: 2. understand how the factors affect the design of structural elements
<b>Assessment criteria</b>
The learner can: 2.1 explain how the <b>factors</b> affect the design of <b>steel beams, steel columns and slabs and built up bases</b> 2.2 explain how the <b>factors</b> affect the design of <b>reinforced concrete slabs, beams and columns</b> 2.3 explain the factors that affect the design of <b>masonry walls</b> 2.4 explain the factors that affect the design of <b>timber beams and columns.</b>

<b>Range</b>
<b>Factors</b> loadings (dead, imposed, wind), pressures (earth, water), limit states, load factors, materials factors, design strengths, sectional properties, stability, durability, fire protection
<b>Steel beams</b> loadings, steel grades, ultimate bending stresses for degree of restraint, bending shear, deflection, bearing, web buckling
<b>Steel columns</b> end fixity, effective length, radius of gyration, slenderness ratio, steel grades, ultimate load capacity
<b>Slabs and built up bases</b> ground loadings, base size, base plates (thickness, holding down bolts, shaft end specification fillet welding, fire protection)
<b>Reinforced concrete slabs</b> loadings, concrete (mixes, strength) steel (types, strength), bending, shear, deflection, curtailment, bond, steel area (max and min), slab details
<b>Beams</b> reinforced concrete loadings, concrete (mixes, strength) steel (types, strength), bending, shear, deflection, bond, curtailment, steel areas (max and min), links, built up shear reinforcement
<b>Columns</b> reinforced concrete braced members, influence of end condition, slenderness ratio limits (short columns), minimum eccentricity, steel reinforcement, steel areas (max and min), linker enforcement, column details
<b>Masonry walls</b> solid: mortar strengths, restraints, effective length, effective height, effective width, slenderness ratio, capacity reduction factor, ultimate load capacity/metre cavity: ultimate loadings, effective height, effective length, effective thickness, lateral support, slenderness ratio, capacity reduction factor, eccentricity ratio, ultimate load capacity/metre

**Timber beams**

joists as beams: material (type, size, grading, associated strength), influence of 'K' factors, bending, shear, deflection, bearing

**Columns**

struts in roofs and stud walls: timber grade, permissible compressive strength, end conditions, effective length, slenderness ratio, modification factor for compression, ratio of modulus of elasticity to compressive stress

**Learning outcome**

The learner will:

3. be able to design structural elements to agreed specifications

**Assessment criteria**

The Learner can:

- 3.1 design **steel beams** and **columns** to agreed specifications
- 3.2 design **slabs and built up bases** to agreed specifications
- 3.3 design **reinforced concrete slabs, beams** and **columns** to agreed specifications
- 3.4 carry out the design of **solid** and **cavity** masonry **walls** to agreed specifications
- 3.5 carry out the design of **timber joists** and **struts** to agreed specifications.

**Range****Steel beams**

restrained, unrestrained

**Columns**

universal columns; axial loads, eccentric loads

**Slabs and built up bases**

for axially loaded columns

**Reinforced concrete slabs**

solid slabs

**Beams**

reinforced concrete, singly reinforced

**Columns**

short columns, axial loads, eccentric loads

**Solid walls**

axially loaded

**Cavity walls**

eccentrically loaded

**Timber joists**

given loadings and span conditions

**Struts**

axially loaded, acting in typical roof truss or vertically in a stud wall, given length and end conditions

<b>Level:</b>	5
<b>UAN:</b>	F/506/9256
<b>GLH:</b>	60
<b>Proposed assessment method:</b>	Assignment
<b>Aim:</b>	<p>To enable learners to apply the knowledge gained from units within Level 5 Civil Engineering learners are required to complete a suitable civil engineering derived project.</p> <p>Learners will be able to demonstrate they are able to</p> <ul style="list-style-type: none"> <li>• develop a Civil Engineering project proposal</li> <li>• scope the project</li> <li>• set project objectives</li> <li>• design solutions to meet project objectives</li> <li>• present the project.</li> </ul>

<b>Learning outcome</b>
The learner will:
1. be able to develop a Civil Engineering project proposal
<b>Assessment criteria</b>
The learner can:
1.1 investigate <b>an area for development</b>
1.2 propose project ideas.

<b>Range</b>
<b>An area for development</b> processes, practices or structures



<b>Learning outcome</b>
The learner will: 2. be able to scope the project
<b>Assessment criteria</b>
The learner can: 2.1 plan roles and activities 2.2 formulate specifications with regard to constraints 2.3 formulate initial proposal(s).

<b>Learning outcome</b>
The learner will: 3. be able to set project objectives
<b>Assessment criteria</b>
The learner can: 3.1 identify information required for inclusion in project proposals 3.2 produce project proposals to required <b>scope</b> 3.3 produce project objectives that comply with health & safety requirements.

<b>Range</b>
<b>Scope</b> e.g increase efficiency; improve customer satisfaction; deliver services more effectively; improvements in quality and output; increase organisation competitive edge; opportunities to expand services; more flexibility; other (to be specified in proposal)

<b>Learning outcome</b>
The learner will: 4. be able to design solutions to meet project objectives
<b>Assessment criteria</b>
The learner can: 4.1 evaluate project variables 4.2 apply numerical reasoning to given scenarios.

<b>Learning outcome</b>
The learner will: 5. be able to present project
<b>Assessment criteria</b>
The learner can: 5.1 present the project solution using appropriate media 5.2 communicate effectively 5.3 present records of project development.

## **Unit 522            Integrated Civil Engineering Design Project**

### Supporting information

This unit will facilitate the learning process by enabling learners to put the theory gained in Level 5 units into practice. Either a work based project or realistic engineering project will be simulated to provide evidence for this unit. Suitable projects may include designing a commercial building, bridge, treatment plant or recreational facility.

<b>Level:</b>	5
<b>UAN:</b>	J/506/9257
<b>GLH:</b>	60
<b>Proposed assessment method:</b>	Assignment
<b>Aim:</b>	This unit develops learners' further understanding of the principles of site surveying and the skills to set out civil engineering works. In addition the unit also develops learners understanding of instruments and software used in civil engineering.

<b>Learning outcome</b>
The learner will: 1. understand the principles of surveying and setting out
<b>Assessment criteria</b>
The learner can: 1.1 compare different types of <b>traverse</b> 1.2 explain the Bowditch method of correction of the misclosure error to a closed traverse 1.3 describe the <b>instruments</b> used in the transfer of control points to upper floors of multi-storey frame structures 1.4 explain the <b>procedure used in the transfer of control points</b> to upper floors of multi-storey frame structures 1.5 describe how to check the verticality of multi-storey framed structure 1.6 describe the <b>procedure used to set out horizontal curves</b> for highway construction. 1.7 describe the use of electronic surveying <b>instruments</b> 1.8 describe the benefits of electronic surveying <b>instruments</b> .

<b>Range</b>
<b>Traverse</b> open, link and closed traverse
<b>Instruments</b> optical plumbing instruments, theodolites, construction laser, autoplumb, plumb bob
<b>Procedure used in the transfer of control points</b> base datum level, Temporary Bench Marks (TBMs)

**Procedure used to set out horizontal curves**

intersection point, tangent points, chainage, tangential angle, long chord  
 computation of deflection angles and chord lengths for horizontal curves

**Instruments**

Electronic Data Measurement (EDMs) , Total Stations, electronic data loggers, GPS (Global Positioning System), lasers, digital terrain modelling

**Learning outcome**

The learner will:

2. know how to use surveying equipment

**Assessment criteria**

The learner can:

- 2.1 explain the **terminology** associated with horizontal and vertical control
- 2.2 describe how to set up and use surveying **instruments**
- 2.3 describe **adjustment procedures** for levelling and angular measuring surveying **instruments**.

**Range****Terminology**

base line, stations, traverse, triangulation, trilateration, grid, intersection, resection, verticality, plumb, angles of elevation or depression

**Instruments**

steel bands, Electromagnetic Distance Measuring (EDM), automatic and dumpy and tilting levels, construction lasers, theodolites (optical or electronic), Total Station instruments

**Adjustment procedures**

temporary and permanent

**Learning outcome**

The learner will:

3. be able to use surveying equipment

**Assessment criteria**

The learner can:

- 3.1 set up surveying **instruments**
- 3.2 complete practical fieldwork surveys
- 3.3 produce contoured plans from the fieldwork surveys.

**Range****Instruments**

steel bands, Electromagnetic Distance Measuring (EDM), automatic and dumpy and tilting levels, construction lasers, theodolites (optical or electronic), Total Station instruments

<b>Learning outcome</b>
The learner will: 4. be able to apply surveying data for setting out
<b>Assessment criteria</b>
The learner can: 4.1 calculate the co-ordinates for traverse stations and apply <b>corrections</b> 4.2 determine the cut and fill requirements from <b>surveying data</b> 4.3 set out horizontal curves.

<b>Range</b>
<b>Corrections</b> Whole Circle Bearings (WCBs), Bowditch method
<b>Surveying data</b> contours, spot height plans, sections

<b>Learning outcome</b>
The learner will: 5. understand the benefits of software applications used in site surveying
<b>Assessment criteria</b>
The learner can: 5.1 explain the <b>benefits</b> of the built in software in Total Stations 5.2 explain <b>Global Positioning Systems (GPS)</b> and their applications to civil engineering works 5.3 evaluate the <b>use of IT</b> to solve typical surveying problems.

<b>Range</b>
<b>Benefits</b> reduction in error, time, accuracy, precise data
<b>Global Positioning Systems (GPS)</b> Advantages: globality, efficiency, accuracy Disadvantages: price, intervisible stations may need to be established, results may need to be transformed into a local geodetic system
<b>Use of IT</b> Global Information Systems (GIS), AutoCAD

<b>Level:</b>	5
<b>UAN:</b>	L/506/9258
<b>GLH:</b>	60
<b>Proposed assessment method:</b>	Dated written paper
<b>Aim:</b>	To introduce the learner to water and wastewater treatment. Learners will develop an understanding of <ul style="list-style-type: none"> <li>• legislations governing water and wastewater</li> <li>• how to identify the nature of sewage and sewerage systems</li> <li>• water treatment</li> <li>• the principles of wastewater treatment</li> <li>• potential Health and Safety risks.</li> </ul>

<b>Learning outcome</b>
The learner will: 1. understand legislation governing water and wastewater
<b>Assessment criteria</b>
The learner can: 1.1 describe the <b>purpose</b> of legislation regarding <b>drinking water</b> 1.2 describe the <b>purpose</b> of legislation regarding <b>wastewater</b> 1.3 describe <b>EU directives</b> with specific regards to water 1.4 describe Health and Safety regulations related to water and wastewater.

<b>Range</b>
<b>Purpose – drinking water</b> palatable, potable
<b>Purpose - wastewater</b> public health, sufficiency, pollution prevention
<b>EU directives</b> governing water and wastewater: the drinking water directive, the wastewater treatment directive and the water framework directive

**Learning outcome**

The learner will:

2. know how to identify the nature of sewage and sewerage systems

**Assessment criteria**

The learner can:

- 2.1 describe the **characteristics of sewage**
- 2.2 compare **sewerage systems**
- 2.3 describe the risks involved when working with sewage and sewerage systems.

**Range****Characteristics of sewage**

physical, chemical and biological, strength and quantity, polluting effects, sources of sewage

**Sewerage systems**

separate and combined systems and how these affect sewage sizing and material, early and present systems, design flows

**Learning outcome**

The learner will:

3. be able to identify sewage and sewerage systems

**Assessment criteria**

The learner can:

- 3.1 determine **sewage flows**
- 3.2 select appropriate sewer size taking into account relevant **factors**.

**Range****Sewage flows**

peak and average flows

**Factors**

population size, industrial activity and infiltration rates

<b>Learning outcome</b>
The learner will: 4. understand water treatment
<b>Assessment criteria</b>
The learner can: 4.1 explain water <b>characteristics</b> 4.2 explain water <b>treatment systems</b> 4.3 describe the steps taken to <b>treat water</b> 4.4 explain the <b>factors</b> to consider when designing sedimentation tanks 4.5 describe appropriate <b>disinfectants</b> to ensure water is safe for consumption 4.6 describe characteristics and criteria for choosing <b>disinfectants</b> for drinking water 4.7 describe the types of <b>wastes</b> resulting from water treatment 4.8 describe the potential Health and Safety risks when working in a water treatment site.

<b>Range</b>
<b>Characteristics</b> quality and standards, physical, chemical and biological
<b>Treatment systems</b> surface (coagulation) and ground water (softening) treatment systems
<b>Treat water</b> coagulation, softening, mixing, flocculation, sedimentation, filtration, disinfection, adsorption
<b>Factors</b> particle size and settling velocity
<b>Disinfectants</b> chlorine, ozone and Ultra Violet (UV) lights
<b>Waste</b> residuals from the coagulation and flocculation process, from backwashing of filters

<b>Learning outcome</b>
The learner will: 5. understand the principles of wastewater treatment
<b>Assessment criteria</b>
The learner can: 5.1 explain the <b>processes</b> used in wastewater treatment dependant on quantity and quality 5.2 describe the <b>sources of sludge</b> 5.3 describe the process for <b>treating</b> sludge 5.4 describe sludge <b>disposal routes</b> 5.5 describe the potential Health and Safety risks when working in a wastewater treatment site.



**Range****Processes**

preliminary, primary, secondary and tertiary treatment processes.

**Sources of sludge**

from preliminary, primary, secondary and tertiary treatment of wastewater

**Treating**

including anaerobic digestion, incineration and emerging treatment processes, e.g. pyrolysis, drying, enzymic hydrolyses

**Disposal routes**

air, land, water and space

<b>Level:</b>	5
<b>UAN:</b>	R/506/9259
<b>GLH:</b>	60
<b>Proposed assessment method:</b>	Assignment
<b>Aim:</b>	<p>The purpose of this unit is to enable learners to develop an understanding of the regulation and funding of transport. Learners will be able to model flows on road networks and public transport services and will be able to design road junctions to accommodate demand.</p> <p>This unit complements Highway Engineering and learners specialising in the area may choose to take both units.</p>

<b>Learning outcome</b>
The learner will:
1. be able to design road junctions
<b>Assessment criteria</b>
The learner can:
1.1 compare different forms of <b>junction</b>
1.2 carry out <b>geometric</b> designs of junctions that are safe and to relevant national standards
1.3 calculate junction <b>capacities</b>
1.4 determine <b>signal timings</b> to optimise traffic networks.

<b>Range</b>
<b>Junction</b> traffic signalised; priority; roundabout; grade separated
<b>Geometric</b> kerb lines; stop lines & give way lines
<b>Capacities</b> ratios of flow to capacity for peak periods of demand
<b>Signal timings</b> Splits; cycles and offsets

<b>Learning outcome</b>
The learner will: 2. understand transport policy
<b>Assessment criteria</b>
The learner can: 2.1 compare different forms of transport <b>regulation</b> 2.2 describe <b>trends</b> in transport and travel 2.3 compare <b>funding mechanisms</b> for new transport infrastructure 2.4 calculate the <b>value</b> of new transport infrastructure.

<b>Range</b>
<b>Regulation</b> state ownership and control of public transport; privatised and deregulated operations; franchising
<b>Trends</b> global and local growth in transport; variations in growth for different transport modes and their causes
<b>Funding Mechanisms</b> road user charging; fares and tolls; state funding; public private partnerships; risks to investors and public
<b>Value</b> Net Present Value; benefit to cost ratios; travel time savings; increased mobility; costs of accidents; costs of construction; operation and maintenance; benefits and costs to the environment and society.

<b>Learning outcome</b>
The learner will: 3. know how to model transport systems
<b>Assessment criteria</b>
The learner can: 3.1 describe <b>methods</b> of estimating <b>trip generation</b> 3.2 describe <b>methods</b> of estimating <b>trip distribution</b> 3.3 describe <b>methods</b> of estimating mode split 3.4 describe <b>methods</b> of estimating traffic assignment.

<b>Range</b>
<b>Methods - trip generation</b> Surveys; growth factor methods; reference to databases
<b>Methods - trip distribution</b> Singly and doubly constrained gravity models; Furness growth factor method; surveys
<b>Methods</b> Discrete choice models including Logit models for given origin and destination pair; surveys
<b>Methods</b> Wardop's first and second principles of equilibrium; all or nothing assignment; traffic counts

<b>Learning outcome</b>
The learner will: 4. be able to model transport systems
<b>Assessment criteria</b>
The learner can: 4.1 use standards <b>methods</b> to predict the <b>trip generation of an area</b> 4.2 use standards <b>methods</b> to predict the <b>distribution of trips</b> 4.3 use standards <b>methods</b> to predict mode split of <b>transport used</b> 4.4 use standards <b>methods</b> to assign traffic to <b>routes and services</b> .

<b>Range</b>
<b>Methods - trip generation of an area</b> surveys; growth factor methods; reference to databases
<b>Methods - distribution of trips</b> singly and doubly constrained gravity models; Furness growth factor method; surveys
<b>Methods - transport used</b> discrete choice models including Logit models for given origin and destination pair; surveys
<b>Methods - routes and services</b> Wardop's first and second principles of equilibrium; all or nothing assignment; traffic counts

## **Unit 525            Transport Engineering**

### Supporting information

Reference should be made to design standards as applicable to the national context.

2.3 – This should include consideration of financial risk to investors and public.

<b>Level:</b>	5
<b>QAN:</b>	J/506/9260
<b>GLH:</b>	60
<b>Proposed assessment method:</b>	Assignment
<b>Aim:</b>	The purpose of this unit is to enable learners to develop an understanding of the processes and procedures used in the measurement, tendering and estimating of civil engineering works, and to use that understanding to measure civil engineering work and produce tenders, estimates and contracts.

<b>Learning outcome</b>
The learner will: 1. understand the principles of measurement, tendering and estimating
<b>Assessment criteria</b>
The learner can: 1.1 describe the procedures used in <b>measurement</b> of civil engineering works 1.2 describe <b>tendering procedures</b> used for civil engineering works 1.3 describe <b>estimating procedures</b> used to cost civil engineering works.

<b>Range</b>
<b>Measurement</b> Civil Engineering Standard Methods of Measurement, elemental, operational or annotated format, interpretation of drawings, identification of components, use of standard terminology, extracting and recording dimensions from scale drawings, interpretation of specifications, preamble and preliminary clauses, use of schedules
<b>Tendering procedures</b> methods (open, selective, negotiated), contractual arrangements (lump sum, serial, term, cost reimbursement, design and build), process (from initial enquiry to tender submission)

**Estimating procedures**

preliminaries, prime costs, provisional sums, preambles, trade sections, summary; general overhead costs, project overhead costs, costs (per functional area, floor area or element), calculation of net unit rate and gross unit rate, use as means of cost control

**Learning outcome**

The learner will:

2. be able to measure civil engineering work from issued drawings and specifications

**Assessment criteria**

The learner can:

- 2.1 use standard methods to measure civil engineering **works**
- 2.2 prepare **Bills of Quantities** from measured works.

**Range****Works**

excavations and fillings, below ground drainage, substructures, superstructures

**Bills of Quantities**

process all measurements, prepare abstracts, write Bill of Quantities in accepted format, bill direct, write clauses, prepare general summary

**Learning outcome**

The learner will:

3. understand how to process tenders

**Assessment criteria**

The learner can:

- 3.1 describe the types of tender contracts
- 3.2 describe methods of tendering
- 3.3 describe the range of **documents** produced as part of the tendering process
- 3.4 explain the **process for tendering** for civil engineering works
- 3.5 describe the process for inviting and receiving tenders.

**Range****Documents**

Bills of Quantities, drawings, specifications, schedules, contracts, relevant information, additional data as appropriate

**Process for tendering**

decision to tender, tender preparation strategy, selection of type of contract to be used and method of tendering

<b>Learning outcome</b>
The learner will: 4. be able to produce a tender documentation
<b>Assessment criteria</b>
The learner can: 4.1 prepare to <b>tender</b> for civil engineering works 4.2 produce tender <b>documentation</b> 4.3 produce post-tender contracts.

<b>Range</b>
<b>Tender</b> select contract and method of tendering
<b>Documentation</b> Bills of Quantities, drawings, specifications, schedules, contracts, relevant information, additional data as appropriate

<b>Learning outcome</b>
The learner will: 5. be able to produce an estimate
<b>Assessment criteria</b>
The learner can: 5.1 prepare ' <b>all-in rates</b> ' for civil engineering works 5.2 produce <b>estimates</b> for civil engineering works.

<b>Range</b>
<b>'All-in rates'</b> labour, materials (to include cutting and other forms of waste), construction plant
<b>Estimates</b> for civil engineering tasks including excavations and fillings, below ground drainage, substructures, superstructures excluding overheads and profit



<b>Level:</b>	5
<b>QAN:</b>	L/506/9261
<b>GLH:</b>	60
<b>Proposed assessment method:</b>	Assignment
<b>Aim:</b>	The purpose of this unit is to enable learners to develop an understanding of pavement maintenance, design and drainage. Learners will be able to design pavement thicknesses, specify materials, design drainage pipe runs and devise methods to rectify pavement defects.

<b>Learning outcome</b>
The learner will: 1. be able to calculate traffic loading
<b>Assessment criteria</b>
The learner can: 1.1 determine pavement design life to design standards 1.2 calculate design traffic accounting for traffic growth 1.3 calculate standard axle loading from standard <b>design factors</b> .

<b>Range</b>
<b>Design factors</b> wear factors; channelization; left/right hand lane factors

<b>Learning outcome</b>
The learner will: 2. understand how to design pavement foundations
<b>Assessment criteria</b>
The learner can: 2.1 explain the <b>role</b> of pavement foundations 2.2 describe subgrade <b>characteristics</b> 2.3 compare <b>design methods</b> 2.4 compare foundation materials.

<b>Range</b>
<b>Role</b> minimise deflection of sub base; drainage; construction traffic; even surface for pavement structure
<b>Characteristics</b> California Bearing Ratios; compressive strength; drainage
<b>Design Method</b> analytical design; performance design; restricted design

<b>Learning outcome</b>
The learner will: 3. understand how to design pavement thicknesses
<b>Assessment criteria</b>
The learner can: 3.1 explain the functions of flexible pavement <b>layers</b> 3.2 describe the <b>benefits</b> of porous wearing courses.

<b>Range</b>
<b>Layers</b> surface course; binder course; base courses
<b>Benefits</b> noise; skid resistance; drainage

<b>Learning outcome</b>
The learner will: 4. be able to design pavement thicknesses
<b>Assessment criteria</b>
The learner can: 4.1 design foundation thicknesses in accordance with relevant national guidance or standards 4.2 select <b>pavement types</b> 4.3 calculate <b>rigid pavement</b> thicknesses in accordance with relevant national guidance/standards 4.4 select flexible paving materials 4.5 calculate flexible pavement layer thicknesses in accordance with relevant national guidance/standard.

<b>Range</b>
<b>Pavement type</b> rigid; flexible; flexible composite
<b>Rigid pavement</b> continuously reinforced concrete roadbase; continuously reinforced concrete pavement; unreinforced concrete pavement; joint reinforced concrete pavement.

<b>Learning outcome</b>
The learner will: 5. be able to design highway drainage
<b>Assessment criteria</b>
The learner can: 5.1 select appropriate <b>drainage systems</b> 5.2 select return period 5.3 calculate <b>design storms</b> 5.4 design drainage <b>pipes</b> .

<b>Range</b>
<b>Drainage system</b> French/filter drains; positive drainage; open drainage <b>Design storms</b> storm intensity; storm duration; time of concentration <b>Pipes</b> pipe material; pipe gradient; manholes.

<b>Learning outcome</b>
The learner will: 6. understand how to maintain pavements
<b>Assessment criteria</b>
The learner can: 6.1 explain the purpose of <b>road condition surveys</b> 6.2 explain the <b>causes</b> of pavement failure 6.3 propose pavement <b>improvements</b> .

<b>Range</b>
<b>Road condition survey</b> deflectograph; scanner; Skid Resistant Pavement Evaluation; visual inspection <b>Causes</b> fatigue cracking; thermal cracking; poor gradation; water penetration; surface wear <b>Improvements</b> full pavement reconstruction; resurfacing; overlaying; surface dressing

## **Unit 527                  Pavement Design**

### Supporting information

#### **Guidance**

Reference should be made to design standards as applicable to the national context including regulations governing the safe construction, design and management of new pavements

<b>Level:</b>	5
<b>QAN:</b>	R/506/9262
<b>GLH:</b>	60
<b>Proposed assessment method:</b>	Assignment
<b>Aim:</b>	The purpose of this unit is to enable learners to develop an understanding of the uses of concrete, the properties of concrete and its constituent parts, the methods, equipment, tools and plant used to produce concrete and the formal methods used to specify concrete mix designs.

<b>Learning outcome</b>
The learner will: 1. know the types and constituents of concrete
<b>Assessment criteria</b>
The learner can: 1.1 describe different <b>types</b> of concrete 1.2 describe the <b>constituents</b> of concrete 1.3 explain how the fineness and chemical make-up of <b>cements</b> affect the properties of <b>concrete</b> 1.4 explain how the <b>properties of aggregates</b> affect concrete 1.5 explain the <b>role</b> of water used in concrete 1.6 compare the effects of different <b>admixtures</b> on concrete 1.7 explain why tests are used to determine the properties of concrete and its constituent parts 1.8 explain the procedures used to determine the <b>properties</b> of concrete and its constituent parts.

<b>Range</b>
<b>Types</b> plain, reinforced, precast, in situ, pre-stressed, post-stressed, lightweight, heavyweight
<b>Constituents</b> cement, fine aggregate, coarse aggregate, water, admixtures
<b>Cements</b> Portland cements (ordinary, rapid hardening, sulphate resisting, white), High Alumina Cement
<b>Concrete</b> fresh and hardened

**Properties of aggregates**

shape, texture, size gradation, moisture content, specific gravity, reactivity, soundness, bulk unit weight

**Role**

workability, setting, hardening, curing

**Admixtures**

air-entraining, water-reducing, retarding, accelerating, plasticisers

**Properties**

compressive strength, workability, density, air content, setting time, aggregate grading, moisture content, silt content, organic impurities, bulking

**Learning outcome**

The learner will:

2. understand concrete practices

**Assessment criteria**

The learner can:

- 2.1 describe the **methods** used to produce concrete
- 2.2 explain **factors** considered in the **reinforcement of concrete**
- 2.3 describe how **plant and equipment** is used in concreting
- 2.4 explain **factors** considered in the use of **formwork and falsework** in concreting
- 2.5 explain **health and safety 'best practice'** to be followed when concreting.

**Range****Methods**

batching, mixing, transporting, handling, placing, compacting, curing, finishing

**Factors - reinforcement of concrete**

appropriately located, bonded, secured and covered

**Reinforcement**

steels bars, fabric mesh, fibres (glass, polypropylene, steel, carbon)

**Plant and equipment**

batch plants, concrete mixers, Ready Mixed Concrete (RMC) lorries, dump trucks, concrete skips, wheelbarrows, pumps, vibrators (immersion and surface), scabblers, power trowels/floats

**Factors - formwork and falsework**

propping, safety, stability, release agents, striking times

**Health and safety 'best practice'**

risk assessments, method statements, compliance with relevant legislation (Health and Safety at Work Act, Management of Health and Safety at Work Regulations, Construction Design and Management Regulations)

<b>Learning outcome</b>
The learner will: 3. be able to design concrete mixes
<b>Assessment criteria</b>
The learner can: 3.1 compare methods used to design <b>concrete mixes</b> in accordance with standards 3.2 design a concrete mix to meet specified <b>parameters</b> .

<b>Range</b>
<b>Concrete mixes</b> nominal, designed , designated, proprietary
<b>Parameters</b> compressive strength at 18 days, workability, maximum water-cement ratio, type of aggregate, maximum aggregate size, minimum cement content

<b>Level:</b>	5
<b>QAN:</b>	Y/506/9263
<b>GLH:</b>	60
<b>Proposed assessment method:</b>	Assignment
<b>Aim:</b>	<p>The purpose of this unit is to enable learners to develop an understanding of essential concepts of sustainable development and the impact of its implementation.</p> <p>On completion of this unit, learners will be able to:</p> <ul style="list-style-type: none"> <li>• analyse environmental challenges</li> <li>• analyse problems posed by the management and development of the built environment</li> <li>• evaluate solutions.</li> </ul>

<b>Learning outcome</b>
The learner will:
1. understand sustainability and sustainable development
<b>Assessment criteria</b>
The learner can:
1.1 describe the aims of sustainability
1.2 explain <b>sustainable development</b>
1.3 explain the <b>threats</b> to sustainability
1.4 describe the aims of international treaties which influence sustainable development.

<b>Range</b>
<b>Sustainable development</b>
history of, theory of, relation with the environment, effect on people's lives, guidelines
<b>Threats</b>
urbanization, excessive consumption, geopolitics, poverty



<b>Learning outcome</b>
The learner will: 2. understand the significance of environmental issues involved with the management and development of the built environment
<b>Assessment criteria</b>
The learner can: 2.1 describe environmental regulation 2.2 describe <b>environmental policies</b> 2.3 evaluate Environmental Impact Assessment (EIA) <b>methods</b> 2.4 explain the principles of <b>Life Cycle Analysis</b> 2.5 describe Health and Safety regulations which impact on environmental development.

<b>Range</b>
<b>Environmental regulation</b> pollution control, resource conservation, land use <b>Environmental policies</b> air, water, waste, contaminated land, noise, hazardous substances <b>Methods</b> Environmental Impact Analysis (EIA) Building Research Establishment Environmental Assessment Methods (BREEAM) Strategic Environmental Assessment (SEA)

<b>Learning outcome</b>
The learner will: 3. understand the concept of green buildings
<b>Assessment criteria</b>
The learner can: 3.1 describe the <b>characteristics</b> of green buildings 3.2 explain the <b>techniques</b> that are used when building 3.3 describe <b>sustainable material</b> used in green buildings 3.4 describe Health and Safety regulations which impact on green buildings during construction and operation.

<b>Range</b>
<b>Characteristics</b> sustainable and efficient processes, design efficiency <b>Techniques</b> water efficiency, rainwater harvesting, waste management and minimisation, water recycling, Sustainable Urban Drainage Systems (SUDS), pollution reduction, improved indoor air quality. <b>Sustainable Materials</b> recycled stone, recycled steel, locally sourced materials



## Appendix 1 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the **Centres and Training Providers homepage** on **[www.cityandguilds.com](http://www.cityandguilds.com)**.

***Centre Guide – Delivering International Qualifications*** contains detailed information about the processes which must be followed and requirements which must be met for a centre to achieve ‘approved centre’ status, or to offer a particular qualification. Specifically, the document includes sections on:

- The centre and qualification approval process and forms
- Assessment, verification and examination roles at the centre
- Registration and certification of candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Frequently asked questions.

## Useful contacts

<b>UK learners</b> <b>General qualification information</b>	<b>T: +44 (0)844 543 0033</b> <b>E: learnersupport@cityandguilds.com</b>
<b>International learners</b> General qualification information	T: +44 (0)844 543 0033 F: +44 (0)20 7294 2413 E: <b>intcg@cityandguilds.com</b>
<b>Centres</b> Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: <b>centresupport@cityandguilds.com</b>
<b>Single subject qualifications</b> Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 F: +44 (0)20 7294 2404 (BB forms) E: <b>singlesubjects@cityandguilds.com</b>
<b>International awards</b> Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: <b>intops@cityandguilds.com</b>
<b>Walled Garden</b> Re-issue of password or username, Technical problems, Entries, Results, e-assessment, Navigation, User/menu option, Problems	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: <b>walledgarden@cityandguilds.com</b>
<b>Employer</b> Employer solutions, Mapping, Accreditation, Development Skills, Consultancy	T: +44 (0)121 503 8993 E: <b>business@cityandguilds.com</b>
<b>Publications</b> Logbooks, Centre documents, Forms, Free literature	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413

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